RADIO HINTS MANUAL

by

"RADIOTRICIAN"

CONTENTS

RADIO TEST EQUIPMENT
MANUAL

Fully Illustrated

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CONTENTS

RADIO HINTS MANUAL

TRANSFORMER TIPS

A tranformer is usually made to perform one task, and will work most efficiently under the conditions for which it is designed, but since the transformer may be regarded as an impedance changing as well as a voltage or current changing device, it is often possible to press an intrument into service of a very different nature from that which it was intended to carry out.

Possibly the simplest example is the use of a mains power transformer as an output transformer. The ratio between the windings of the output transformer is given by the formula

$$R = \sqrt{\frac{\text{Stated Anode Load}}{\text{Speech coil impedance}}}$$

so that in the case of a loudspeaker with a speech coil impedance of 3 ohms, which is to be used with a 6V6 output valve, the valve's anode load is first ascertained from Data Tables such as Bernard's Valve Manual, No. 30. For a certain set of conditions the output load for the valve is 8,500 ohms, so that the above formula becomes

$$R = \sqrt{\frac{8\,500}{3}}$$

$$= \sqrt{2,833}$$

or   53 nearly.

Thus the required ratio of the transformer is 53 : 1.

In the case of the conventional mains transformer it will be seen that several ratios are readily available, and whilst the transformer is wound in such a way that there will, be some attenuation of the upper frequencies, this will almost certainly be no worse than the attenuation which occurs in the ordinary commercial output transformer of the lower priced grade, and except when used with high fidelity apparatus, reproduction will be unimpaired for all practical purposes.

The mains transformer rated at 350-0-350 volts, 6 volts and 5 volts with the usual 220-240-250 primary has the following ratios, using various windings or parts of windings.

Whole primary to whole secondary 250 : 700 or 3 : 1 near
Between 220 and 240 taps on
    primary to 5 volt winding ...   20 : 5 or 4 : 1
220 volt primary to 5 plus 6 volt
    windings in series   ...   ...   220 : 11 or 20 : 1,
240 volt primary to 6 volts   ...   240 : 6 or 40 : 1'
Whole primary to 5 volts   ...   250 : 5 or 50 : 1
Half seconary to 5 volts   ...   350 : 5 or 70 : 1
Whole secondary to 5 volts   ...   700 : 5 or 140 : 1
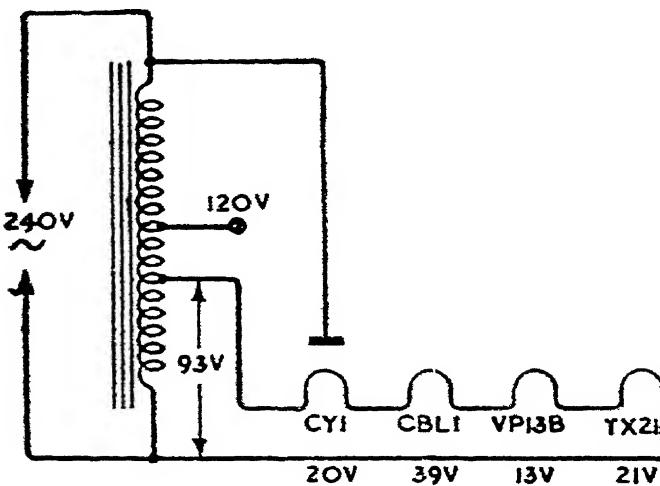
Fig. 2. (*above*)
Heater Chain and H T. Tap
supplied by an Auto-Transformer
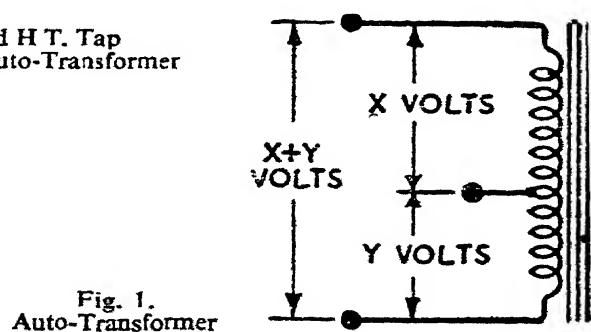
Fig. 1.
Auto-Transformer

Further ratios are also obtainable by combining windings in
series as in the case of the 20 : 1 ratio, where two heater wind-

ings are connected in series. It is necessary to take precautions when joining windings in this way so that the ends of the windings are not crossed—that is, so that the windings are in phase. The simplest test is to run the transformer on power, joining the two secondaries giving 6 and 5 volts so that they combine to light a 12 volt bulb almost to full brilliance. If they are connected out of phase only 1 volt or so will be supplied, and the same conditions will obtain when the windings are used for any other purpose.

Having considered the mains transformer as an output transformer, it is, presumably, only fair to state that the reverse also holds good. The small pentode type of output transformer will give approximately 4 volts A.C. across its secondary terminals when the primary is connected to the 240 volt supply, and whilst efficiency will not be high, the output will be sufficient to run one or two valve heaters. This scheme should only be used as a makeshift, however, for the transformer will run hot, and fuses should be included in the circuit connected to the mains.

WINDING TRANSFORMERS

A transformer will only supply power under the correct conditions when its windings, as well as being in the correct ratio one to another, are also matched to the power to be drawn from or supplied to a circuit. The building of power transformers is discussed in No. 48 of Bernard's List, but the outstanding points may be repeated here.

CROSS SECTIONAL AREA OF THE CORE

The number of turns in the coils of the transformer depend largely on the area of the core, and the power output possible also depends on the same factor. Supposing a transformer capable of delivering 6 volts at 4 amps was required, the output of the secondary is thus 24 watts (or, more properly, since the output is A.C. 24 volt-amps).

The formula

$$A = \frac{\sqrt{W}}{5.58}$$

where A is the area of the core and W is the watts supplied gives A in square inches. Thus for the above case the core

7

would need to have an area of at least 1 square inch after allowing for the :—

EFFICIENCY

Transformers have losses, like other apparatus, although in a well designed instrument they are small. The efficiency of a small transformer may be taken as 70%, so that the primary watts will be not 24 but $24 \times \dfrac{100}{70}$ or 35 nearly. Thus the core area should be worked out on the basis of the primary watts.

TURNS PER VOLT

The number of turns in each winding of the transformer depends on the voltage across the winding, the magnetic qualities of the core, the area of the core, etc., and may most simply be expressed by the formula

$$N = \frac{V}{.11\,A}$$

where N is the number of turns of wire on the winding under consideration, V is the voltage supplied to or by the winding and A is the cross sectional area of the core in square inches. Thus for the small 6 volt transformer with a 240 volt primary, to be wound on a 1 inch core, the primary winding is

$$N = \frac{240}{.11 \times 1} \quad \text{or} \quad \frac{240}{\cdot 11} \quad \text{or} \quad 2{,}180 \text{ turns}$$

Similarly, the secondary winding is

$$N = \frac{6}{\cdot 11 \times 1} \quad \text{or} \quad \frac{6}{\cdot 11} \quad \text{or} \quad 54 \cdot 5 \text{ turns}$$

The current in each winding must be considered, so that a suitable gauge of wire is chosen. For the 4 amp secondary 16 gauge would be ideal if there is room on the former, whilst for the primary the current may be determined by dividing the watts, 35, by the volts, 240, the current thus being ·15 amp. which will be carried safely by 32 gauge wire. The wire used for winding transformers should be new enamelled wire, without kinks or weak spots in the insulation. One shorting turn in any winding makes the whole instrument useless. The windings must be carefully insulated from each other and from the core.

AUTO-TRANSFORMERS

The auto-transformer consists of only one winding, as shown in Fig. 1, so that the circuits connected to it are not insulated one from the other. This is of little importance in many applications, however, and one easily made auto-transformer can be of great use to the experimenter who works with both 6-volt and 4 volt valves. A 6 : 4 volt transformer allows both types of valve to work from one mains transformer giving either heater voltage, and since the wattage is low a small core, such as that obtained from an old intervalve transformer, may be used. Wire to give about 3 amps at the 4 volt tap—18 gauge enamelled copper—should be suitable, the details of the windings being worked out as above. The wire is then wound on the former until the 4 volt winding is all on, a flexible lead being soldered to the wire at this point and led out through a hole in the former The bared wire and joint are very carefully insulated and further windings for another 2 volts are then laid on, an extra 2 or 3 turns being given to compensate for losses. The former is then taped over and the core inserted.

With the whole winding across a 6 volt supply, 4 volts will be available at the tap, or the tapped portion of the winding across a 4 volt supply will give 6 volt across the whole winding.

Note that rectifier heaters must never be supplied in this way. They are connected to high voltages, and must always have a separate, highly insulated, heater winding on the mains transformer.

POWER SUPPLIES FOR THE MIDGET RECEIVER

Popular as has become the midget American type receiver, there are disadvantages attendant upon its use, not the least of which is the heater power supply. In general, this type of set is designed to work from 110 volt mains, so that in some cases the heater chain requires 110 volts, high voltage heater valves being used in series, whilst in other cases only a small dropping resistor is necessary. Running the set on 240 volt supplies, however, means that a series resistor to drop 130 volts is required, and this is most often supplied in the form of line cord, since there is not room in the cabinet for a wire wound dropping resistor. A barreter could be used, but unless the heater chain required 110 volts a further resistor would be required to give the 100-110 volts H.T. supply.

Since the usual heater current is 2 amps the drop along

9

the line cord will dissipate at least 65 watts probably more, whic his uneconomical and often unsafe, whilst many cases are on record where a line cord has been "cut to length" by an unwary set owner, with consequent rapid failure of the valves.

Fig. 2 shows a typical heater chain supplied by a transformer of the auto type, a method which also provides for a H. T. tap. Such a transformer, like the auto transformer for 4-6 volts previously mentioned, can be wound with little trouble, and accommodated behind the set or near the power point with perfect safety, since there is no heating to any degree and insulation can be assured by enclosing the transformer in a simple case. Moreover, the method is far more economical of current, since only the small transformer losses have to be taken into account.

In designing the transformer by any particular case the load to be handled must, as usual, be the first consideration in order that a suitable size of core may be chosen. In the case illustrated, where the heater chain requires 93 volts and the whole supply voltage may be fed to the rectifier anode, the watts are taken as $93 \times .2$, or 18 6 watts to be supplied, whilst allowing the transformer efficiency to be 80% the wattage on which the minimum core area is based is 24. Thus the minimum core area is below one square inch, and a core of one square inch area would be ideal.

The size of the windings is calculated using the formulae already given, although when choosing the wire sizes it must be borne in mind that the efficient transformer has the winding space neatly filled – that is, the wire must be chosen so that the windings fill the core. The 93 volt winding supplies 2 amp to the valves, and since this larger winding will have greater losses than the usual heater winding, the resistance must be kept low by using the heaviest gauge of wire possible, whilst 28 S. W. G. will carry .3 amp with safety, a much larger wire should be used at least 22 S. W. G. enamelled copper. The remainder of the winding, across which will be a potential of 147 volts, will carry approximately $\frac{24}{240}$ or .1 amp (total wattage divided by supply voltage), and here 30 S.W.G. wire would be satisfactory.

This means that the 93 volt winding should be laid on the former first, with its ends brought out for the heater supply, the commencement of the 147 volt winding being soldered to

the last turn of the heavier wire, the joint being carefully insulated, a layer of Empire Tape or similar material separating the two windings.

Where an H. T. tap is required, when using valves of the Pentode-Rectifier type, a further tap is brought out at the suitable point. Since the majority of these valves are rated at 125 volts on the rectifier anode, a half-way tap giving 120 volts would appear to be most convenient For small currents in the H.T. circuit the wire gauge will hardly be affected, but for higher currents the additional wattage should be calculated and provision made for the extra power.

All the leads from the transformer may be of lighting flex, the heater supply leads being kept as short as is possible to avoid losses. The transformer may be mounted in a wooden case.

It will be understood that the use of the auto-transformer described in the last chapter enables the receiver to be operated on A. C. current only.
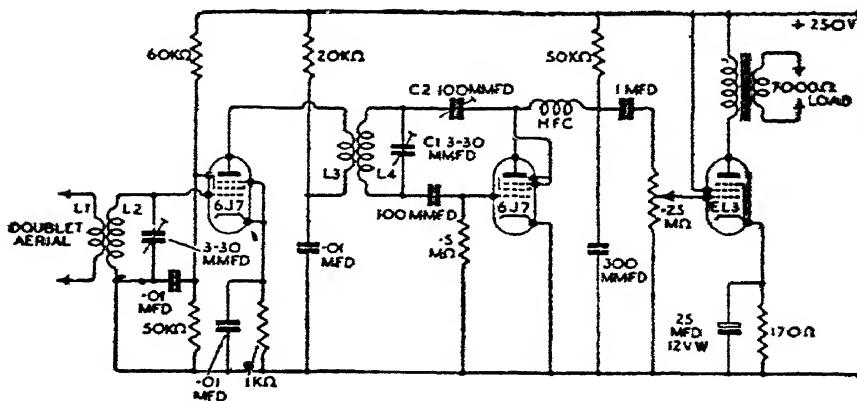
Fig. 3. Television Sound Receiver.
L1=L3= 3 turns 22 S.W.G. enamelled D.C.C. ⎰ Close wound, ½' former
L2=L4=12 ,, 18 ,, ,, .. ⎱ ⅓' between coils.

A TELEVISION SOUND RECEIVER

It is well known that the sound programme from the B.B.C. television station is of very high quality, due to the fact that the sidebands carrying the modulation frequencies can extend

over a relatively greater bandwidth than that allowed for the normal broadcast programmes, thus giving a greater audio frequency range. The receiver circuit given in Fig 3 is designed for reception of the sound television programme, and can be built up as a pretuned set with no controls other than an on-off switch and volume control, thus allowing a small neat cabinet to be used.

It will be seen that reaction is used in the detector circuit, but whilst this type of detector introduces some distortion in the higher wavelengths, at the sound programme frequency reaction can be used to a greater extent without trouble.

The receiver is built on a copper or aluminium chassis, a carefully planned layout being used to give short and direct leads to the high frequency circuits. Ceramic valveholders should be used for the first two stages and the semi-variable condensers used for tuning and reaction control are ceramic based air trimmers. The two tuning coils may be purchased or made, and consist of 12 turns of 18 S W.G. copper wire wound to a ½in. diameter, the turns being spaced by their own diameter. The coils are wound on paxolin tube formers and are mounted directly across the air trimmers, which in turn are mounted to give short grid leads to their respective valves.

The aerial coil consists of 3 turns made in a similar manner and supported in line with the tuning coil of stage 1, the disdance between the coils preferably being variable until the set is finally adjusted, when the aerial coil can be set in position permanently.

A source of well smoothed H.T. is required to enable the fullest advantage to be taken of the high quality signal, and, if required, the output from the reacting detector can be fed into a quality amplifier and the last stage of the receiver omitted.

To tune the set an insulated trimmer tool should be used to avoid hand capacity effects. Increase the capacity of C2 until the detector stage is on the threshold of oscillation, then, with C1 at its lowest capacity, slowly increase the capacity until the station is tuned, temporarily coupling the aerial to the tuning coil of the detector stage should the signal be weak or difficult to find. Finally, trim the H.F. stage for greatest volume and then reduce the capacity of the reaction condenser, C2, to the lowest permissible limit. Make sure that the station fundamental frequency is tuned, and not a harmonic.

12

Best results, of course, will be obtained by the use of a correctly cut vertical doublet aerial erected in the open and at a good height   Such an aerial may consist of a half wavelength of wire or rod, preferably copper, cut at the centre and supported there by an insulator.   From either side of the insulator there will thus be a 5-foot length of aerial, and an 80 ohm feeder ; obtainable commercially, should be joined to either side of the aerial at the insulator, the two feeder wires running directly to the aerial coil of the receiver.

AN "S" METER FOR AMATEUR RECEPTION

Most amateur transmitting stations, when giving reception reports, now include the strength of the signals being received at their stations by reference to an "S" reading, this value being taken directly from an "S" meter, or Field Strength Indicator incorporated in the receiver.   Such a meter can be built into a superhet circuit with little trouble, and can be used not only for comparing the received strength of signals, but will also indicate day-to-day fluctuations in reception conditions.   The calibration and scaling of the meter is, of course, purely arbitrary, the general reports giving degrees of strength from S1 to S9, although decibel readings are sometimes given.
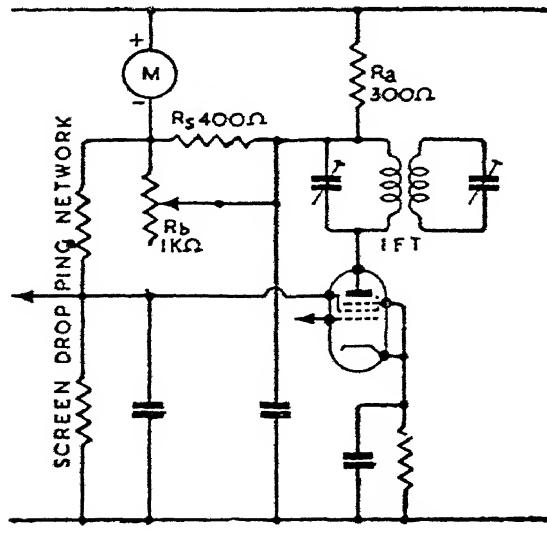
Fig. 4
An 'S'
Meter
Circuit

13

The "S" meter is a 0-1 mA. instrument, connected into the anode supply line of a variable-mu I.F. amplifying valve, as shown in Fig. 4. The circuit is actually a type of bridge, so arranged that the meter can be balanced to zero reading when no signals are received, the change in anode current of the valve giving an indication of signal strength when a station is tuned.

To enable the meter to be balanced the currents through the two arms of the bridge Ra and Rs must be approximately equal at no signal point, the current through Rs remaining steady at all times. This current is generally that used in the screen dropping network for the screen supply to the R.F. and I.F. valves, and, given the anode current for the bridge arm Ra, the load on the arm Rs can generally be adjusted to a suitable figure without much trouble. The receiver is set at full volume with no signals being received to balance the meter to zero by means of Rb.

GRAMOPHONE PICKUPS

Since a great number of gramophone pickups suffer with age, it is desirable to have a working knowledge of their construction. It must be pointed out, however, that the Crystal type of pickup should be returned to its makers for any necessary adjustment or repair. The following notes refer only to magnetic pickups, which are generally of the damped armature type. Some pickups, known as needle armature pickups, are arranged so that the steel needle is in the magnetic circuit, but in either case a piece of magnetic material is caused to vibrate in accordance with the record track characteristics. The vibrations of this armature have the effect of varying the magnetic flux or field strength which surrounds a coil of wire within the pickup, when by the well known method of induction small currents are set up within the coil and corresponding varying voltages appear across the coil, these voltages being fed to the grid of the first amplifying stage of the reproducer.

In Fig. 5 is shown an expanded view of the usual type of magnetic pickup. The armature is suspended within the pole pieces by rubber, so that its movement is damped, and it is the deterioration of these rubber members which causes the loss of quality in an old instrument. Their replacement is simple, however. On the spindles of the armature two suitable lengths

of cycle valve tubing will be found ideal, whilst the top damping pad, which must be made to fit snugly into its metal retaining frame, may be made from a piece of thick sheet rubber such as a piece of car inner tube.

Dismantling the pickup should be treated as a delicate operation, since the windings of the coil are fragile and easily damaged. It is most important in the re-assembly of the instrument to position the top damping pad correctly. The tongue of the armature is held in a slit in the pad and must be so placed to bring it centrally between the pole pieces. Any inclination to one side or the other will lead to chatter—that is, the armature will touch the pole pieces on loud passages, with consequent distortion and possible damage to pickup and record.
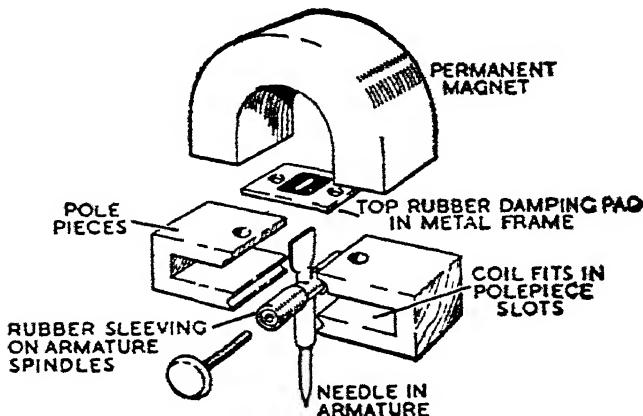
Fig. 5. Exploded View of Magnetic Pick-up

The rewinding of damaged pickup coils is painstaking and monotonous work, whilst a rewound coil often gives reduced output due to the lesser number of turns which can be put on when using a heavier gauge of wire than the original machine wound gauge In an endeavour to simplify the repair of pickups the author devised the plan of winding a very small coil directly on to the armature itself, the reduced impedance of the coil together with its minute output being matched into the amplifier by a transformer. Results were excellent, the pickup on which the experiments were performed having a better response curve than with the original coil.

15

The method of winding such a coil is illustrated in Fig. 6 Number 40. · S.W.G. D.S.C. copper wire is used, wound in net layers directly on to the armature in the space between the spindles and the tongue, and the amount of wire which can be accommodated will vary widely in different makes of pickup. In the case quoted 100 turns were laid on, and if desired the winding may be secured with a coat of very thin shellac. The weight added to the armature must be kept as low as possible, but in most cases it should be negligible.

The winding must be clear at all points from the pole pieces, since if it is allowed to touch during the armature's vibration the result once again will be buzzing or chattering.

The leads from the coil are led out between the pole pieces and taken out through the tone arm in the usual way.

Matching the pickup to the amplifier must, in general, be experimental, although for those with access to an A.C. Bridge the measurement of the impedance of the coil at 400 cycles per second will give a valuable basis from which to work. It must be realised the D.C. resistance of the coil cannot be taken into account for the purposes of matching, since the impedance at 400 cycles will be a very different figure. Supposing this impedance to be 200 ohms, and the amplifier has a required input impedance of a quarter megohm, which is often the case, then the transformer ratio is given by

$$R = \sqrt{\frac{250,000}{200}} \text{ or a ratio of } 35 \cdot 4$$

When the matching has to be done experimentally, however, it is necessary to use a multi-ratio transformer, and for this purpose the details given in Transformer Tips on page 2 may be of help. Once a suitable matching ratio is found an input transformer might be specially wound, and here the method given for winding output transformers may be used. The primary and secondary windings should be sectionalised and. interwound, and since, in the input transformer, practically no current is flowing, good frequency coverage should be obtained.

Careful magnetic screening of the input transformer will be found essential, and it must be mounted as far away as possible

from power supplies, mains transformers and chokes, since it is very liable to pick up hum. Leads from the pick up to the transformer and from the transformer to the amplifier must be screened, and the transformer core earthed through the screening to the chassis. The volume control, if used in the first stage, must be across the secondary winding.

MEASURING INSTRUMENTS

All experimenters feel the need for a range of measuring instruments at some time or another, but a single meter with a full scale deflection of 1 milliamp can be made to cover a wide field of voltage and current measurements by the addition of resistors in series and parallel with the instrument

In choosing the ranges to be covered, it is a wise plan to make them direct multiplications of the scale figuring of the instrument, and since in most cases the 1 milliampere scale is in five divisions, each division being sub-divided to ten lines, giving a fifty line scale, the most easily read values for the meter will be

5, 50, 250, 500, 1,000 volts, D.C.
1, 5, 50, 500 milliamps, D.C.
100, 1,000 volts, A.C.

It will be noticed that no provision is made for measuring A.C. milliamps. This is for the reason that a current transformer is required, the transformer necessarily being wound to suit the characteristics of the tester circuit, a task beyond the workshop capabilities of the average home constructor.

Since a 1 milliamp instrument has a circuit resistance of 1,000 ohms per volt the resistors are simply calculated as being 5,000, 50,000, 250,000, 500,000 ohms and 1 megohm for the D.C. volts ranges given above, the accuracy of the reading depending directly on the accuracy of the resistance value. Precision resistors of 1% accuracy are obtainable, but for most radio test purposes 5% is considered a sufficiently accurate reading, and there is little point in using resistors more accurate than the instrument itself. It will be appreciated that the internal esistance of the instrument will be added to the external resistance on each range, but this will cause little effect except on the 5 volt range, where it can be allowed for if desired. The resistance of the instrument should be stated on the scale, or it may be obtained on a bridge, and if the correction is to

be made this internal resistance must be subtracted from the 5,000 ohm resistor. For example, if the instrument's resistance is 100 ohms, the 5,000 ohm resistor must be decreased to 4,900 ohms.

When making or ordering the resistors for the A C. volts ranges, the impedance of the rectifier must be taken into account, the figure being around 800 ohms. For the two ranges, above, 100 and 1,000 volts A.C., this again will have only a negligible effect, the inaccuracy introduced being less than that rated for the rectifier itself, so that non-inductive resistors of 100,000 ohms and 1 megohm may be used for these voltages, but should it be required to read a low voltage of the order of 5 or 10 volts the rectifier impedance must be deducted from the resistance values. However, the further disadvantage arises that for any voltage of less than 100 the A.C. calibration will not be linear—that is, the scale readings on the instrument will only be accurate at the top mark, with a progressive error down the scale. For low A.C. volts measurement, therefore, a second set of calibration points will have to be put on the instrument, a task for the experienced worker only.

Unfortunately, also, allowing for the rectifier impedance is not sufficient if accurate results in measuring A C. volts are required. The rating of a 1 milliamp rectifier is the A.C. rating, and the D.C. outpuut is, naturally, somewhat lower, so that for a full scale reading on the instrument with 1 mA. A C. flowing the meter sensitivity requires to be between 8 and 9 mA., or, in other words, if the ranges are adjusted by the means just outlined there will be an error of about 10% or even more.

The simplest method of overcoming this defect is to cali-brate the instrument for A.C. by the simple means of reducing the series resistor so that slightly more than 1 mA. is flowing through the rectifier. Whilst this also means that at full scale the rectifier is overloaded the ranges suggested allow for this, since it will be unlikely that full scale readings will be required. Thus, for the 1,000 volt range make 80% of the series resistor fixed with the other 20% a wire wound resistors which can be stripped down to a reduced value. Connect the instrument, with the full resistance in series, to a known source of A.C —230 volts main, for example, and reduce the wjre wound resistor, *switching off for each adjustment*, until the meter reads a correct 230 volts. Similarly, any A.C. range can be

18

adjusted for an accurate reading, the calibrated source being chosen to suit the range.
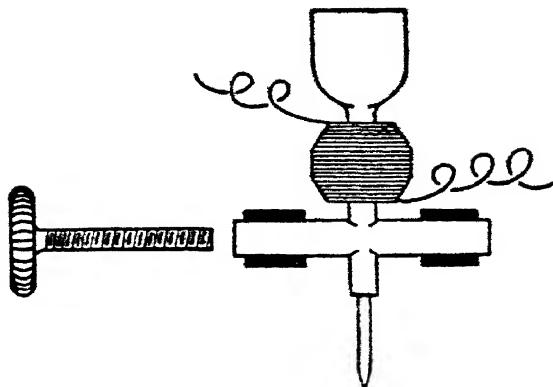

Fig. 6
Rewinding Coil
on Pickup
Armature
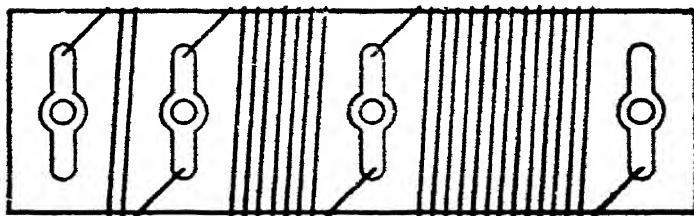
Fig. 7. Shunts Wound on Paxolin strip

The shunts for the D.C. current ranges will have to be wound to suit the instrument, since they depend entirely upon the instrument's own resistance, but the work can be performed with a fair degree of accuracy without the use of a second calibrated milliameter. Manganin wire should be used for the shunts, which can be wound on paxolin strip, fastened at either end to a soldering tag, as shown in Fig. 7. Heavy gauge wire will be used for low resistance, high current shunts, 22 S.W.G. being suitable, whilst 34 S W.G. wire will be adequate for the lower current shunts, double cotton covered wire being used in each case.

To determine the shunting resistance without the use of a resistance bridge or a second calibrated instrument, proceed as follows :—

Take the 1 milliamp instrument to be shunted and connect it to a battery via a variable resistance, so that 1 Ma. is passed. Thus for a 3 volt battery a rheostat of maximum resistance of 3,000 ohms would be needed, for 30 volts 30,000 ohms, etc. Set the instrument to top mark.

Solder the end of a length of 34 S.W.G. manganin wire to a tag on the paxolin strip, connecting the tag through a *short* length of thick copper wire to one of the meter terminals. To the other meter terminal connect a similar short copper wire to the end of which is soldered a razor blade. Gently pressing the blade on to the manganin wire will make a contact through the cotton covering, and the length of wire between the tag and the blade will then be in shunt with the instrument. Part of the current will flow through the wire, so that the instrument reading will fall, and it only remains to find the point at which the instrument reading falls to ·2 Ma. This means that four-fifths of the original current of 1 Ma is flowing through the shunt, so that the instrument reading at full scale will now be 5 milliamps, the first range required.

Bare the wire at the discovered point, cut to length with a quarter inch to spare, tin the spare end and solder to a second tag. The 5 milliamp shunt is then complete.

Note that the razor blade must be used with care to avoid weakening the wire, and that the manganin must be well cleaned and tinned with a hot iron. Do not use acid fumes for such soldering ; resin flux gives as good a joint with no chance of corrosion.

For determining the 50 milliamp shunt, use the instrument as before but with the 5 milliamp shunt connected across it. Set to full scale deflection and again shunt with a length of 34 S.W.G. manganin, this time reducing the 5 Ma. reading to a reading of .5 Ma. The reading is thus multiplied by 10, and 50 milliamps will be needed to bring it to full scale. The 500 milliamp shunt, wound with 22 S.W.G. wire, is made similarly, by using the 50 milliamp shunt across the instrument and reducing the reading, with the extra shunted length of wire to 5 Ma. Here the multiplication is 10 again, so that 500 Ma. will be needed for full scale deflection.

It must be realised that whilst quite satisfactory accuracy can be obtained by this method, an error in one shunt will be

multiplied up in proportion when that shunt is used to deter-mine another. Careful work, therefore, is needed to obtain good accuracy on all ranges.

For those with access to a resistance bridge, the work may, of course, be done more directly by using the formula

$$S = \frac{R}{(X-1)}$$

where S is the resistance of the shunt, R is the resistance of the instrument itself and X is the factor by which the range is to be multiplied.

Fig. 8.
Multi-range Circuit
Tester

1. 1 Ma. D.C. High Ohms
2. 5 Ma. D C. Med. Ohms
3. 50 Ma D.C. Low Ohms
4. 500 Ma. D C.
5. 5 V. D C.
6. 50 V. D C.
7. 250 V. D C.
8. 500 V. D.C.
9. 1,000 V. D.C.
10. 100 V. A C.
11. 1,000 V. A.C
12. Off
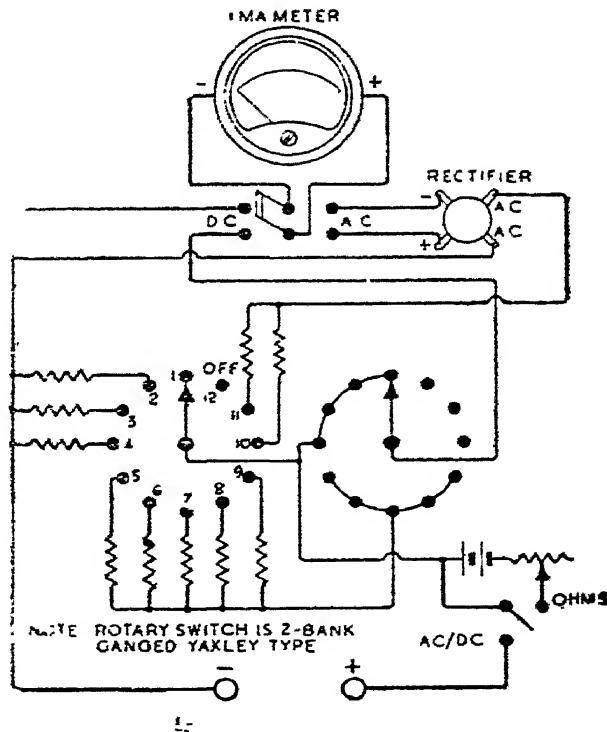
In Fig. 8 is shown the circuit diagram of a multi-range test set, or analyser, using the series resistors and shunts so far described. In addition, it will be seen that provision is also made for measuring resistance, although this may be performed with any milliameter on hand with a fair degree of accuracy.

21

All that is required is a battery and a variable resistance of such value that full scale deflection can be obtained on the
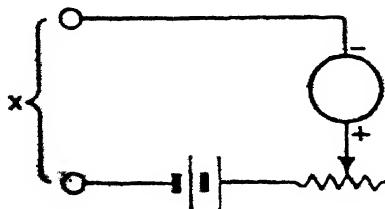

Fig. 9.   A simple Ohmeter

instrument when it is connected in the circuit of Fig. 9, and the "X" terminals are short-circuited.

Thus, as before, using a 1 Ma. meter and a 3-volt battery, a 3,000 ohm rheostat will be required.   Adjust the instrument to full scale deflection, break the circuit between the "X" terminals and insert the resistance to be measured.   The meter will give a new reading, and the value of the resistance is obtained from the formula

$$X = \frac{R. \, I_1 - R}{I_2}$$

where X is the unknown resistance, I_1 is the full scale current reading, I_2 is the current reading with the unknown resistance in circuit and R is the internal resistance of the test- set, con-sisting of meter, battery and rheostat.

$R = \dfrac{1,000 \, V}{I_1}$ where V is the voltage of the battery used.

Note that in the analyser of Fig. 8 the resistance ranges are multiplied by using the shunted milliamp ranges, thus changing the values of R for the circuit and extending the resistance ranges.

The simplest method of calibrating the instrument for resistance measurements is to draw up a graph using several calculated points on the current scale, corresponding to I_2, when other values of X can be read off and multiplied for other ranges also.

22

CHECKING THE SUPERHET OSCILLATOR

When checking the oscillator circuits of commercial receivers, as well as those of home-built or experimental sets, a simple method of detection of oscillation is a great advantage. The method to be described also shows the value of the oscillator grid voltage, which in many circuits is the injected voltage, and allows its linearity over the waveranges to be inspected.

In Fig. 10 is shown a typical frequency changer circuit of the triode-hexode type, with direct grid oscillator injection. The oscillator triode has its grid connection to the cathode via a 50,000 ohm resistor, and since in an oscillating circuit the grid is driven positive, this resistor is passing grid current and is therefore also causing a potential difference to be set up across its ends, thus biasing the triode section of the valve automatically.

The method of checking is to break the earthy end connection of the grid leak for the insertion of a milliameter as shown, an instrument with a 1 Ma sensitivity being suitable for the test.

If oscillation is not taking place the instrument will not record any deflection, and will only read when the triode is oscillating.

Application of Ohm's Law will allow the grid voltage to be calculated. If the instrument is recording ·2 Ma through a 50,000 ohm resistor, the voltage across its ends, disregarding frequency effects, is $V = \dfrac{\cdot 2 \times 50{,}000}{1{,}000} = 10$ volts, and the grid voltage may be adjusted to a suitable value, discovered from the makers' valve data sheets, by adjustment of the size of the grid condenser, an average value being ·0001 mfd. as shown. If it is desirable to increase the voltage, the condenser must be made larger, but to decrease the voltage the condenser may be reduced or a second method used, that of shunting the oscillator anode coil with a resistance. A suitable trial value is 20,000 ohms, connected directly across the anode coil.

N.B. In some circuits the anode coil acts as the tuned coil, the grid coil being untuned. The untuned coil must always be the shunted coil.

When the voltage on the oscillator grid is at a suitable value it may be tested for linearity over the waverange by tuning the set through its full adjustment. The oscillator voltage should remain substantially constant, but serious deviations may be smoothed out by combined adjustments of grid condenser and anode coil shunt, the adjustments being made simultaneously.
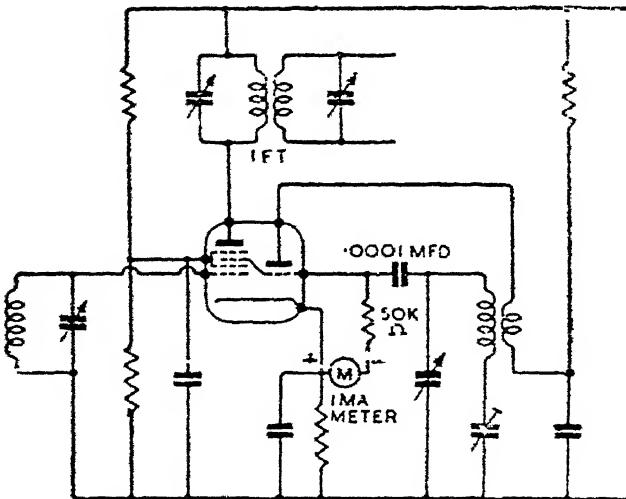
Fig. 10. Checking the Superhet Oscillator

n oscillator working at a low injection voltage gives a weak signal, whilst one working at a high injection voltage is liable to cause spurious signals to appear, due to the setting up of harmonics.

A MULTI-PURPOSE AMPLIFIER

Being in need of a small but powerful amplifier for a range of uses, the author developed the circuit shown in Fig 11, which has proved its worth on many occasions. The original model is built on a very small tinplate box measuring only $6'' \times 3\frac{1}{2}'' \times 1\frac{1}{2}''$ since it was made to plug into an existing power pack, but the circuit as given would require more space for the mounting of the supply equipment. It should still be built on a steel or iron chassis, however, to take advantage of the shielding thus provided.

24

It will be seen that both valves have a measure of negative feedback provided by the omission of bias condensers, so that tone is excellent. Rather more sensitivity is gained by the inclusion of a 25 mfd. condenser across each bias resistor however.
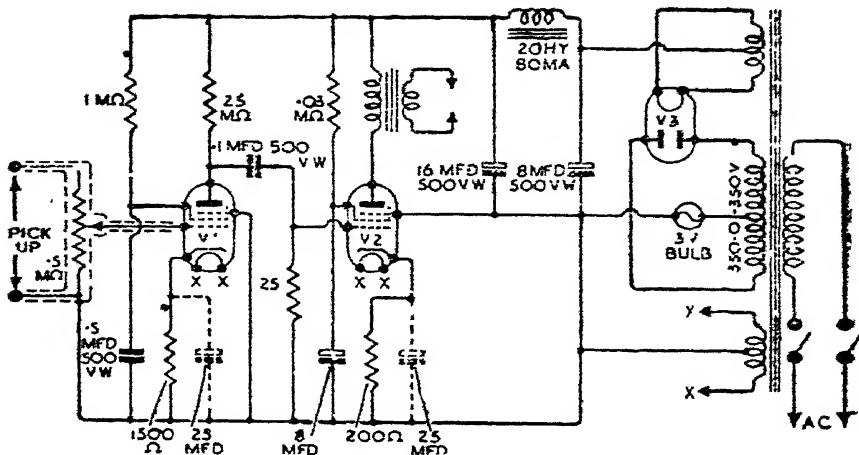
Fig. 11. General Purpose Amplifier

6 volt working : VI EF39 V2 PPGC or EL3. Output load 7000 Ω. V3, 5Y3.
4 volt working : VI SP41 V2 PEN 45. Output load 5,200 Ω. V3, UU6.

Whilst the output valve is slightly overrun by the maker's figures, no ill effects have been observed, and the amplifier has filled a fair-sized hall from a sensitive pickup, whilst volume from any pickup is adequate for a large room. In addition, the amplifier has now been fitted with a power socket from which other units may be fed, and the V.H.F. receiver, described on page 40, is used regularly with the amplifier to provide excellent reception of 10 metre band amateur stations and other signals, at full loudspeaker strength.

Alternative valves for 4-volt heater working are listed, and require no change of component values, apart from a load adjustment on the output transformer.

The U.U.6 rectifier, however, should have the H.T. positive read connected to its cathode pin and not to a centre tap on the heater winding.

25

RADIO TUNING STAGES FOR AMPLIFIERS

A simple tuning stage for broadcast reception which can be added to the input side of an audio amplifier with the minimum of extra connections and trouble, can add largely to the usefulness of the equipment, and the circuits of Figs. 12 and 13 show two such stages, one designed for a good reception area, and one for a low signal strength area.

The first stage consists of a single infinite impedance detector, a stage which will not overload with a strong signal and which gives at the same time, a highly quality sound output. Extremely little plate current is drawn, and the audio output is earthed, which ensures that no hum will be introduced into the amplifier circuit through poor decoupling or regulation.

The volume control shown in the output side can be omitted should the input sockets of the amplifier lead straight into a volume control, and the lead from the cathode condenser taken straight to the amplifier, but in either case this lead should be screened, the screened outer conductor serving as the earth return.

In the second circuit an H.F. stage precedes a triode detector to give a measure of amplification to weak signals. Both stages are tuned through a two gang condenser and should be built on to a metal chassis, either that of the amplifier, if there is room, or on a separate chassis, and screened so that there can be no interaction between the tuning coils. The circuits are trimmed in the usual way for ganging, the tuner being set to a weak station of low wavelength and trimmers for maximum volume.

A SHORT WAVE REACTING DETECTOR

The short-wave listener who uses the small oscillating type of receiver, particularly in mains operated circuits, requires very smooth reaction in order that the signal may be brought up to maximum strength with complete stability and lack of threshold howl. In general, oscillation is obtained by the use of an anode coil inductively coupled to the grid tuned circuit, the degree of oscillation being varied by a "throttle control" condenser. A better method, however, which although it has been in use for some years, still is not widely known, is
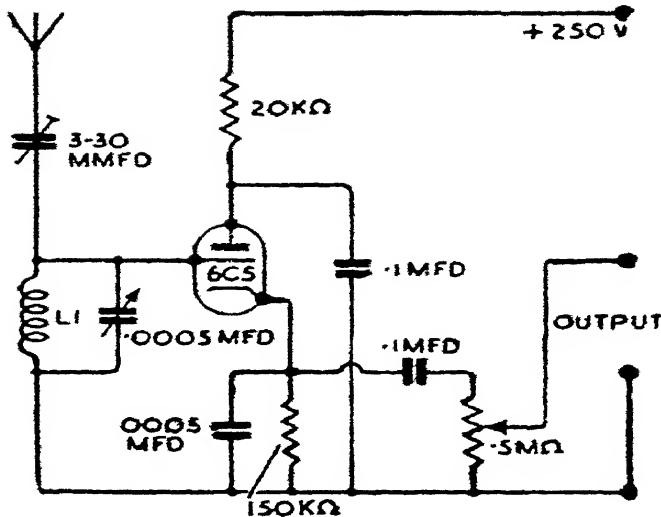
Fig. 12. Straight Detector for use with Amplifier
L1 = Wearite PHF 2
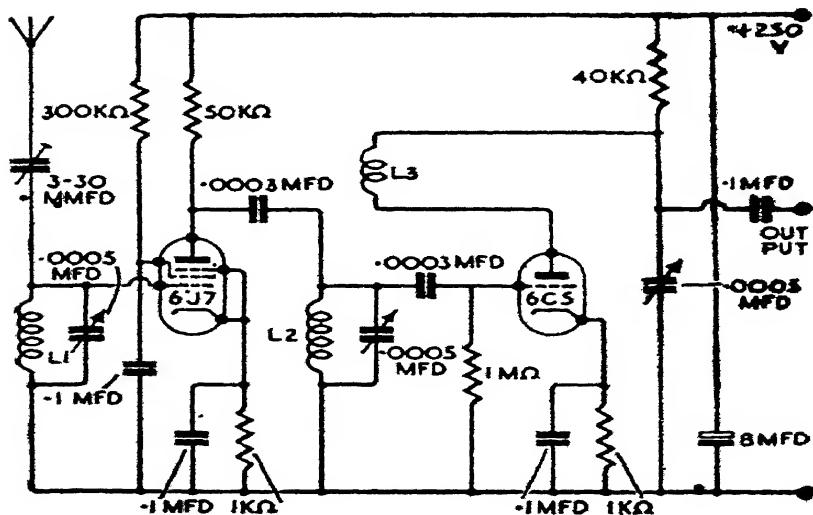
Fig. 13 Double Tuning Stage for use with Amplifier
L1 = Wearite PA2
L2 = Wearite PHF2

27

to introduce reaction in the cathode circuit by means of a feedback coil, the degree of oscillation being controlled by varying the screen potential of an H.F. pentode or tetrode. Control is smooth and effective, and a second advantage is the reduction in coil and former size, made possible by the fact that no coupling is introduced between the grid and cathode coils. Indeed the cathode coil may well be a H F. choke, mounted below the chassis and screened from the tuned components.

The circuit is shown in Fig. 14 as the first stage in a simple receiver to give headphone reception. Should a greater power output be required for loudspeaker operation, the secondary of the transformer, instead of feeding the 6C5, may be taken to the input terminals of the all-purpose amplifier described on page 29. Decoupling of the power circuits will be required in this case, obtained by including a 20,000 ohm resistor in the lead from transformer to H.T. and by-passing the connecting point of the transformer and resistor with an 8 mfd. condenser to earth. An H.F. stage may be added to the receiver, as described on Page 29. The H.F. chokes in the cathode and anode circuits should be of different makes to avoid interaction.
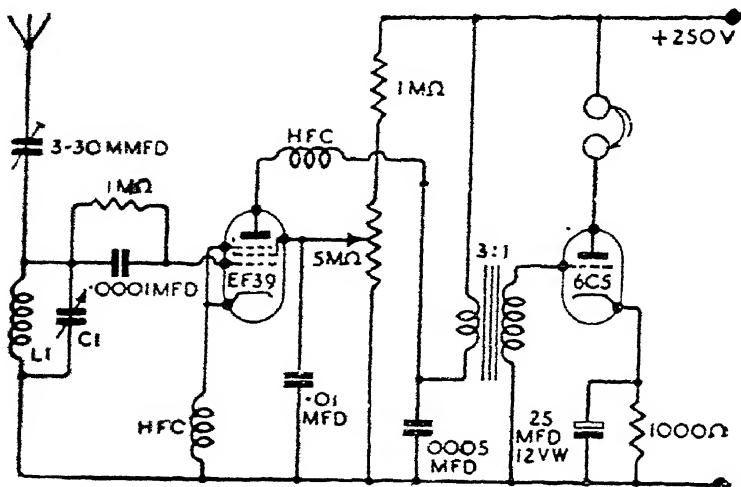
Fig. 14. A Short-wave Reacting Detector. L1 as in Fig. 25

28

H.F. STAGES FOR SHORT-WAVE RECEIVERS

With the return of amateur transmission, on the higher frequency short wave bands, the older type of short wave receiver will exhibit some lack of selectivity and will also require more gain to bring in weak signals. The reacting detector is also noted for its "deadspots"—the tuning points where the aerial's natural frequency, or its harmonic, is matched to the receiver's frequency, with a consequent loss, or serious reduction of, oscillation. To combat this only a small degree of coupling is possible between the aerial and receiver, which results in further reduction of weak signals, whilst interference from the reacting stage can be radiated.

A tuned H.F. stage overcomes most of these difficulties. Aerial coupling can be tighter, deadspots are not formed, selectivity is improved, and with a well made stage a useful degree of amplification is obtained.

With the circuits shown in Figs. 15 and 16, separate tuning of the H F. stage is illustrated, but if the stage is to be built into a receiver, a pair of condensers suitable for ganging can be used, the tuning of the two stages being controlled from one dial by coupling the variable condensers with a flexible or similar link. Condensers suitable for ganging are the Raymart VC160X. It is quite satisfactory, however, to use separately tuned stages, as will have to be done where the H.F. stage is added to an existing set, although the tuning is simplified by using identically similar coils and condensers for the new stage as are included in the existing detector stage.

The R.F. amplifier is built up in its own screened box, or, if it is built on to the set chassis, is arranged within a screened compartment so that feedback and interaction cannot occur. Power supplies may be drawn from the receiver, since the consumption of the stage is small, and the circuits give details for both a battery and a mains operated H F. amplifier.

Operation is simple, since all that is required is to set the receiver on the edge of oscillation in the usual way and then to tune both condensers, keeping them in step as well as possible. It will be found, however, that the detector stage tuning is a master control and that the H F. stage tuning can be corrected for greatest volume after a station has been received.
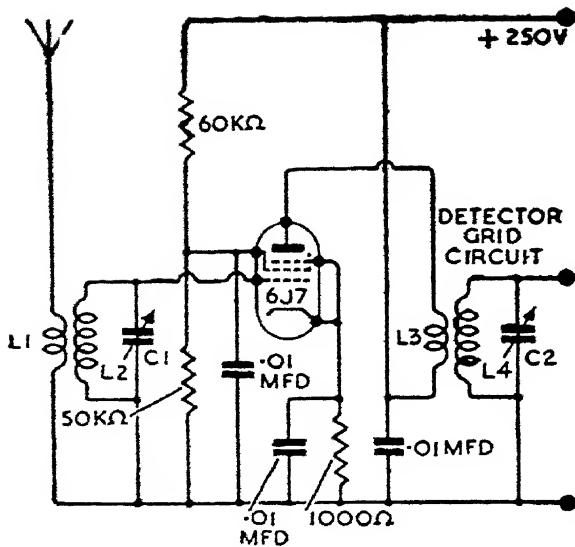
Fig. 15. Short Wave H.F. Stage. L1 and L2 as L3 and L4. L3 being Grid Coil of Detector Valve, or use values as in Fig. 25. C1 as C2

With a circuit such as shown in Fig. 16, all the condensers, including the reaction condenser C_3, will acquire extension spindles in order to obviate hard capacity effects.
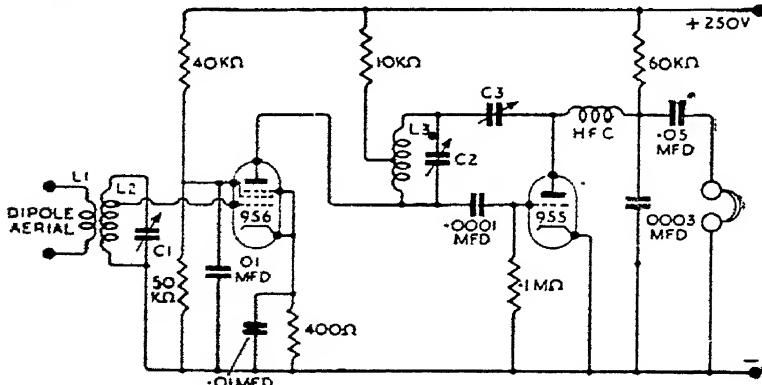
Fig. 16. V.H.F. Acorn H.F. Stage directly coupled to Reacting Detector
C1=C2=40 mmfd. C3=100mmfd. L2=L3=18 turns 18 S.W.G. $\frac{1}{2}$'' dia.
for 10 metres. L1=3 turns loosely coupled to L2

Better results may be obtained by tapping the grid lead to the 956 a quarter of the coil turns down the coil from the top end, thus reducing the input valve load on the coil as shown.

If desired the detector stage can be made super-regenerative as in Fig. 27 provided that the isolating condenser C_2 is retained in circuit.

TONE CONTROL METHOD FOR PICKUPS

For high quality reproduction of gramophone records it is necessary not only to have some means of reducing treble or high frequencies (the usual "tone control" fitted to radiograms and amplifiers), but owing to the nature of the recording itself
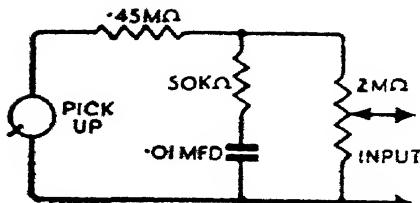
Fig. 17. Bass Boosting Pick-up Network to give ·5 m Ω input load
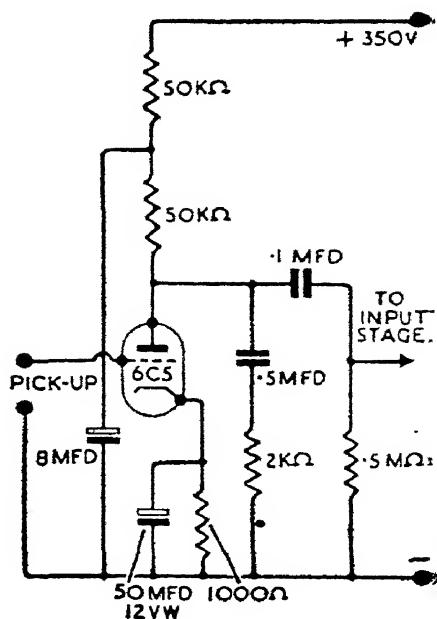
Fig. 18. Bass Boosting Input Stage

31

some method of "bass boost" is required.

Below a frequency of about 250 c.p.c. the amplitude of the bass notes is automatically reduced in the recording gear in order that the recording stylus shall not swing sufficiently far to weaken or break down the walls between adjacent grooves. Thus there is a progressive loss in the lower frequencies which should be made good in the reproducing gear.
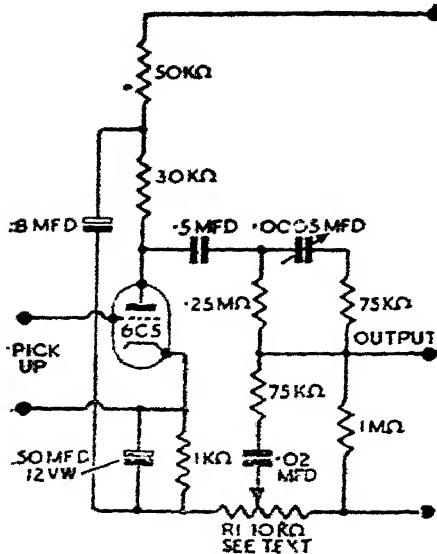
Fig. 19.
J. E. Varrall's Tone Control Stage (*By kind permission of the Designer and* "Wireless World")

Naturally the simplest method of so doing is to suppress the unaffected frequencies to the same level as the bass, and circuits to perform this function are shown in Figs. 17 and 18.

In Fig. 17 is shown a network which is connected between the pickup and the amplifier input terminals to give a partial amount of correction. It is not always realised that the mechanical features of the pickup generally give a certain degree of bass boosting due to resonance effects, so that the filter circuit should not give too much correction. Such a filter may be made to match the impedance of an amplifier, where this is known, the circuit giving an impedance of ·5 megohm with the values shown. The apparent volume from the pickup will be reduced considerably, so that this type of

filter is only suitable for use with apparatus with a reserve of power. It is, moreover, not suitable for use with a crystal pickup, which already has a response curve giving some bass boosting.

Where the attenuation of the middle and high frequencies gives insufficient input to a small amplifier a type of boosting preamplifier as shown in Fig. 18 should be used. Here the filter network is in the anode and coupling circuits, and is shown connected directly to the following valve.

"A tone control stage, however, is more versatile than a set level of boosting, and in the circuit of Fig. 19, first published by J. E. Varrall, in "Wireless World," May, 1939, a very wide range of control is possible using only a limited number of components. One virtue of the circuit is that the control, R1, acts as a tone compensated control. This means that the tone correction, as set for any record, appears to be equal over a range of volume obtained by operating R1, whereas with other types of circuit operation of the volume control results in apparent change of tone.

It must be noted that the input to the grid of the stage is above earth, so that hum can be introduced into the circuit unless careful shielding of pickup leads is arranged. Other types of input apparatus which have to be connected to earth will include R1 in their circuit and gain will be reduced to a large extent owing to feedback across R1.

Whilst R1 acts as a tone compensated control, it is really the main tone adjustment, and an ordinary volume control must be fitted to a later stage in the amplifier, tone setting being carried out by simultaneously operating this volume control and R1 to maintain apparently equal volume at different degrees of correction.

MAGIC-EYE TUNING INDICATORS

When a receiver is under construction it is worth while to consider the fitting of a tuning indicator, a device which can also be fitted to an existing receiver with little trouble. The most suitable stage from which the driving voltage for the Magic-Eye can be derived is the A.V.C. diode of a superhet, although a single diode detector without A.V.C. can also be used. It is preferable, however, not to connect the tuning

33

indicator to the demodulation diode since the shunted load may cause slight distortion, and in the case where a single diode is fitted this can be changed for a double diode which will also provide A.V.C. to the preceding stages of required.

Operating voltages for the indicator can also be obtained from other types of detectors, however, and most simply from the anode bend detector.

The circuits for the tuning indicator are shown in Fig. 20, where it is used with a single diode, in Fig. 21, where the single diode is changed for a doub'e diode, and in Fig. 22, where it is used with the anode bend detector.
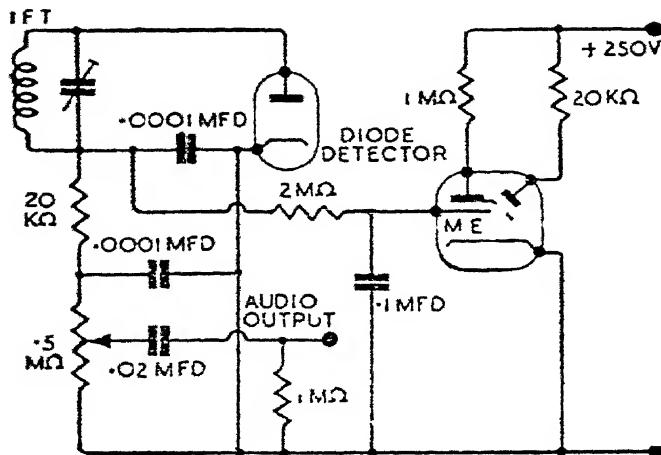
Fig. 20.
Magic Eye connected to
Single Diode Detector

Since the Magic Eye uses only little power, both for heater and H.T., practically any type of receiver power pack will take the extra load without any trouble.

Where the tuning indicator is to be used with existing sets it will most simply be fitted to those with a translucent tuning dial of celluloid or similar material. The Eye in its holder should be fitted behind the dial at an angle which gives clear vision from the usual operating position, preferably centrally in

34

the tuning dial, and a hole cut in the dial to accommodate the vision end of the valve.

One rule to be observed when using the Magic Eye with a diode circuit is to keep the cathode of the tuning indicator at about the same potential as that of the diode. This is accomplished in the diagrams by earthing both cathodes, but in some cases, notably where delayed A.V.C. is being used, or where the diode forms part of a diode triode, the cathode of the demodulator will be above earth by perhaps 3 of 4 volts. In this case the cathode of the Magic Eye can be biased by running it to a tapping on the cathode resistor of the output valve, the tapping being chosen to give the same potential as that on the diode cathode. This method can only be used with a Class A type of output where the current through the valve is substantially uniform.

ADD-ON UNITS FOR RECEIVERS AND AMPLIFIERS

Where it is required to use a gramophone pickup with the smaller type of receiver, not fitted with pickup input terminals, the double problem of connecting in the pickup and also of obtaining sufficieut volume is encountered. It is generally necessary to use a pre amplifying stage, which aggravates the existing problem, for it is now necessary to draw power from the receiver to work the extra valve.

The best solution is that which will avoid disturbing the set wiring, which can be done by using a power and input adaptor, constructed from a valve base and holder.

When a pre-amplifier is to be used with a receiver it will feed into the output stage, whilst it is also most convenient to draw the extra power from this point. The output valve is removed. the adaptor, to be described, plugged intothe output valve socket, and the valve replaced in the adaptor.

A base similar to that of the output valve must be used and the system is of greatest convenience when a valve of the beam power tetrode or pentode type is used in the output circuit.

This will mean that in most cases the valve base required will be of the octal type.

35

At suitable points round the base drill holes in the side, two for heater leads, one for earth or negative connection, one for H.T. power and one for grid input from the pre-amplifier. Into the pins of the valve base solder lengths of tinned copper wire, one length to each pin.

Next, measure the leads from the receiver to the pre-amplifier, keeping them as short as possible, and cut to length, using twisted flex for the heater wiring, and a separate rubber covered conductor for the H.T. power supply. The grid input
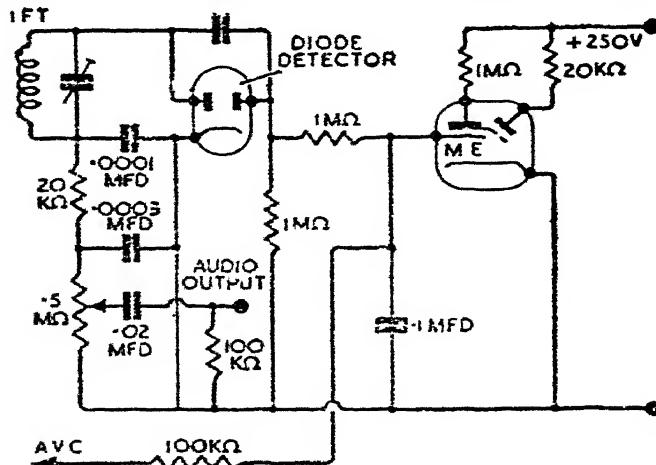
Fig. 21. Magic Eye used with Double-Diode Detector
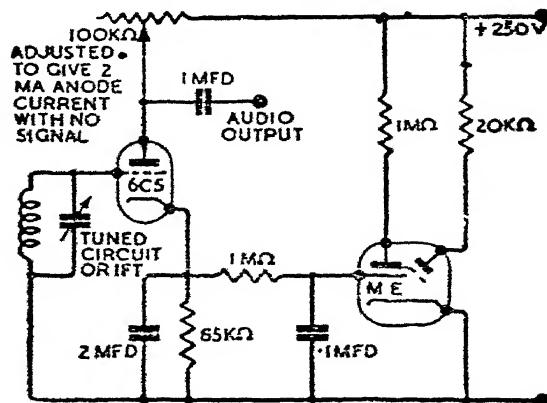
Fig. 22.

Magic Eye used with
Anode-Bend Detector

36

lead and negative connector lead will be combined, since a shielded cable must be used for the grid line, and the shield will act as the negative connector.

On to the wires already soldered to the valve pins slip very short lengths of insulating sleeving, so that the wire is covered from the top of the pin to the level of the holes drilled in the side of the valve base, and run the pre-amplifier leads through their respective holes and solder them with small neat joints to the correct wires inside the base.

The heater leads will be connected across the heater pins, the grid lead will be connected to the grid pin, whilst the H.T. power line will be connected not to the anode pin but to the screening grid pin. The anode connector will have signal voltages upon it, and so cannot give the power supply for the pre-amplifier.
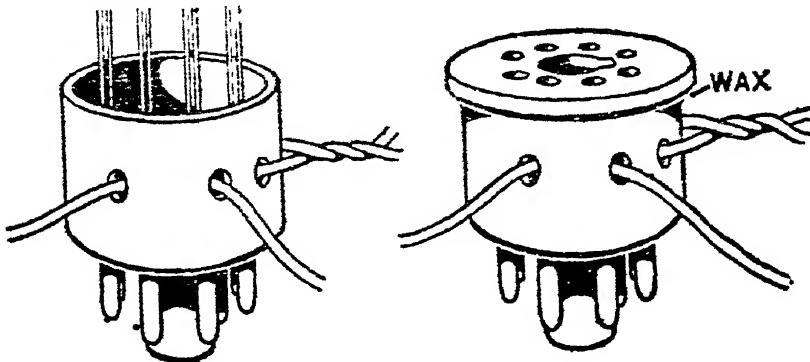
Fig. 23.

Valve Base with wires soldered to pins   Valve Holder soldered to wires and
  and tapping leads brought out   cemented or waxed to base

In the same way the negative connector must not be led to the cathode pin of the valve base, for this would result in extra current being drawn through the bias resistor, upsetting not only the output valve bias but causing feedback. Instead the negative connector, the metal sheathing of the screened lead, must be connected to the earthed internal screening pin. In the case of an output valve without an internal earthed screen, the negative connector is not taken into the valve base at all, but is equipped with a strong clip and clipped on to any convenient part of the receiver chassis.

37

Further short lengths of insulating sleeving are then run over the upright lengths of wire, and the valve base filled with melted sealing wax or sealing compound, leaving the ends of the wires from the pins protruding. These are cut to as short a length as will permit their being soldered to a valve socket of the flat wafer type, the valve socket being, of course, identical with that in the receiver, the wires going each to its correct pin. The valve socket should be as close a fit on to the top of the valve base as possible, and when all joints are made, further melted wax or compound used to fix the socket and valve base firmly together. It is desirable to plug a valve into the socket before this final sealing to ensure that the connecting plugs are properly positioned. If this is not done it must be remembered that the wax will need clearing away from the spigot hole of the socket before the valve can be inserted.

Diagrams of the finished adaptor are shown in Fig. 23.

The preamplifier circuit recommended for a pickup is shown in Fig. 24. A triode gives all the amplification required, and
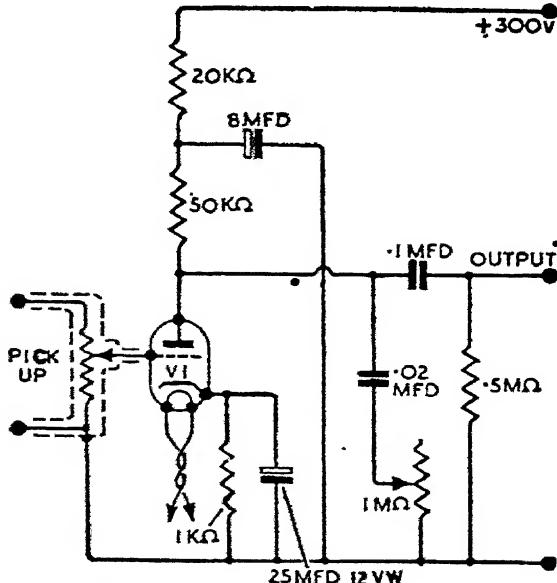
Fig. 24. Pick-up Pre-Amplifier
For 6v working V1=6J5
For 4v working V1=AC2HL

38

the unit contains its own volume control, high note cut-off, and the coupling components to the next stage. The volume control of the receiver, when using the adaptor described, may or may not have an effect on the output, depending on the receiver circuit. In some cases it may be found necessary to turn the receiver's volume control practically to the "Off" position.

Note.—The adaptor cannot be used with D.C. or A.C./D.C. receivers, since the extra heater lead cannot be drawn from these sets without internal modification.

The adaptor is only suitable for use with a transformer-driven A.C. set.

Insulation inside the adaptor must be perfect. Should a short circuit occur between the base pins, great damage may be caused.

On occasions it may be desired to use the adaptor for taking a power supply only, as when using a converter with a receiver where the input is fed into the aerial stage. For these applications it is only necessary to build the adaptor omitting the grid input lead and using a separate rubber-covered wire for the negative connector.

A circuit for such a short wave converter is given in the diagram of Fig. 25, which may be used with a sensitive medium and long-wave receiver, either straight or superhet. The incoming waves are mixed with local oscillations in the converter, the beat frequency so produced being passed on the aerial circuits of the receiver which is suitably tuned, generally to about 550 metres. The broadcast receiver then acts as an I.F. amplifier and second detector, or, in the case of a superhet, as a second frequency changing stage and I.F. amplifier.

It will be seen that the converter has two tuning controls, since the oscillator and mixer are tuned separately. This is found to be quite good practice on the short wave bands, and any inconvenience caused by the separate tuning of the stages is repaid by the accuracy of the ganging.

In tuning the converter, the main control is the oscillator tuner. The mixer tuning control should be kept roughly in step with the oscillator, and signals brought up to volume with this control once the station has been located. When first lining up the converter it will be found advantageous to use a signal

generator where possible, so that two tuning dials can be calib-rated to frequency points and thus more easily kept in step. Details of the tuning system are as follows :—

C1 and C2, ·r001 mfd. variable tuning condensers.
   20 metre band.

L1. 3 turns 18 SWG, $\frac{1}{4}''$ from grid end of L2.

L2. 9 turns 18 SWG, spaced own diameter.

L3. 6 turns 18 SWG, spaced own diameter.

L4. 4 turns 18 SWG, enamelled wire, $\frac{1}{4}''$ from grid coil.
   40 metre band.

L1. 5 turns 20 SWG. $\frac{1}{4}''$ from grid end of L2.

L2. 20 turns 20 SWG, spaced own diameter.

L3. 13 turns 20 SWG, spaced own diameter.

L4. 6 turns 20 SWG, enamelled wire, $\frac{1}{4}''$ from grid coil.
   80 metre band.

L1. 8 turns 24 SWG, $\frac{1}{4}''$ from grid end of L2.

L2. 45 turns 22 SWG, close wound.

L3 30 turns 22 SWG, close wound.

L4. 9 turns 24 SWG, enamelled wire, $\frac{1}{4}''$ from grid coil.
   All coils on $1\frac{1}{4}''$ diameter formers.

A HOLDER FOR THE ACORN VALVE

The Acorn valve, as bought, is supplied with small copper clips which need attachment to the apparatus in which the valve is to be used, and whilst in some cases the makers advise that the clips be mounted on a copper plate with mica separators, this method giving adequate H.F. by-passing for ultra high frequency work, this method is not always possible or desirable.

An excellent low-loss holder can be made for the Acorn by using a piece of $1\frac{1}{4}''$ diameter paxolin coil former. Cut off a 1″ length of former, filing the ends smooth, and mark out as shown in Fig. 26, drilling small holes at the indicated positions for 9 or 10 B A. bolts. Bend the copper mounting clips at right angles just above the two fixing holes, and bolt the clips to the former so that the Acorn will be suspended between them, with its base inside the former.
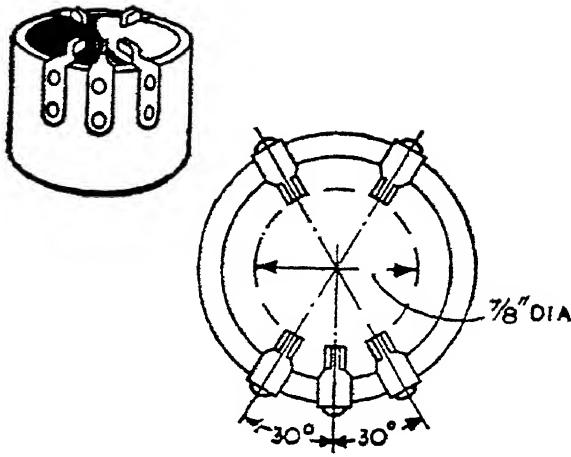
Fig. 26. An Acorn Valveholder
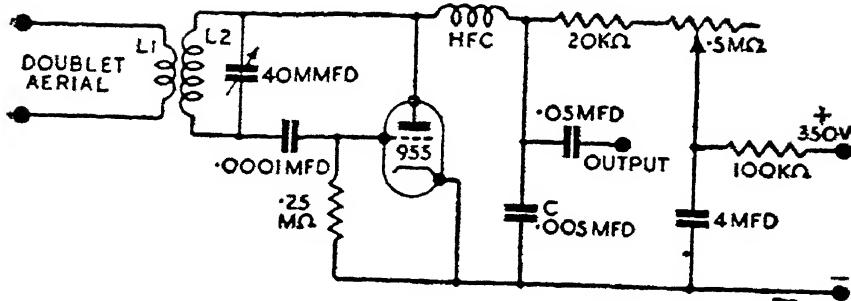
Fig. 27.

Super-Regenerative U.H.F. Receiver

L1 : 3 turns 18 SWG 1/2" dia

L2 : 2-4 metres. 3 turns 18 SWG 1/2" dia turns slightly spaced.
 3·5-7 metres, 10 turns 18 SWG 1/2" dia turns slightly spaced
 5.5-11 metres, 19 turns 18 SWG 1/2" D.C C. turns touching

In a good reception location north of London, however, the circuit of Fig. 27 has given excellent results on many widely spaced stations, including Americans, most of which have been sufficiently well received to break through the quench entirely and give full loudspeaker volume on the amplifier described on page 45.

42

The super-regenerative receiver, in operation, is well known for the loud hissing noise or "quench" characteristic of it, the porperty which enables the circuit to tune broadly on a sharply defined signal with very great sensitivity. Briefly, "quenching" consists of superimposing a low frequency oscillation on to a circuit already oscillating at its working frequency, with the result that the receiver is held at its most sensitive point. The circuit as shown provides its own quench through the agency of R and C, and the condenser must be chosen with care to suit the circuit conditions A trial value of ·005 mfd. is shown, which generally gives smooth operation, but other values can be tried.

The original model is built on a sheet of 14 gauge copper, 6″ × 4″, the tuning condenser being mounted at one end on an insulating bracket and driven through a short extension rod from a slow motion dial. The rod not only obviates the chance of hand capacity, but isolates the tuning condenser from the moving metal parts of the vernier device, since metallic friction near the coil or connected to the condenser can set up disturbing noises. The Acorn is connected directly through its grid condenser to one side of the tuning system, the anode being taken to the other side by a very short 18 gauge bare copper lead. All earth connections are taken directly to the cathode clip which is strapped directly to the copper base The importance of these short connections cannot be stressed too highly, for not only can long leads upset the tuning ranges by adding inductance to the circuit but the high frequencies they carry can set up interference or intercoupling and are prone to loss by leakage.

The choke is wound on a ¼″ ebonite rod which carries the connecting leads of stiff copper wire to which the choke winding is soldered at either end, the component thus being self-supporting. The winding consists of 36 S W.G. enamelled copper wire, wound in a single layer with turns touching.

The decoupling resistor is also self supporting and is mounted on the output terminal block. In the original receiver the resistors are fixed to give an optimum working voltage, but a refinement which will enable valves with slightly different characteristics to be used without trouble is the variable resistor shown in the power supply line.

By means of this control the circuit is brought to the point where quenching is just audible, further adjustment being made when a signal is received.

The power supply for heater and anode is drawn via a four-pin plug from the amplifier chassis as described on Page 45, but any power pack will supply the necessary current.

The output circuit is for feeding into either headphones or amplifier, and the coupling condenser of ·05 mfd. gives perfectly adequate headphone strength without any change in circuit. It is found preferable to couple headphones by this method rather than to run the H.T. supply through them in the conventional manner since any leakage of the high frequencies into the head phone leads gives a de-tuning effect which is entirely absent when using the resistance-capacity coupling.

The aerial as used with the original sets is a simple dipole cut to resonate at 10 metres, connected through twin feedrs to a 3-turn aerial coil, supported on an insulated pillar at the same level as the tuning coil. The dipole is used as an indoor aerial, each half being 79″ long, supported from a central insulator. From either side of the latter runs the feeders, which may be of any length, though no longer than is necessary. For indoor work flex as used for lighting circuits is perfectly suitable, althogh for an outdoor aerial weatherproof material would be required. Aerial coupling is variable by swinging the aerial coil, an average distance of ¼″ from the grid end of the tuning coil being found satisfactory.

Coil changing is effected by plugging the coil ends into closely fitting sockets which are mounted directly on the rotor.
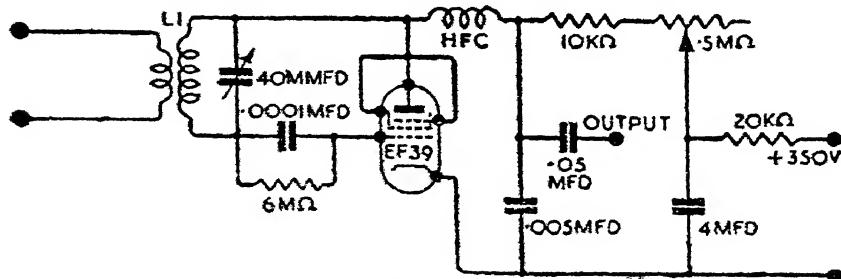
Fig. 28. Super-Regenerative U.H.F. Receiver

44
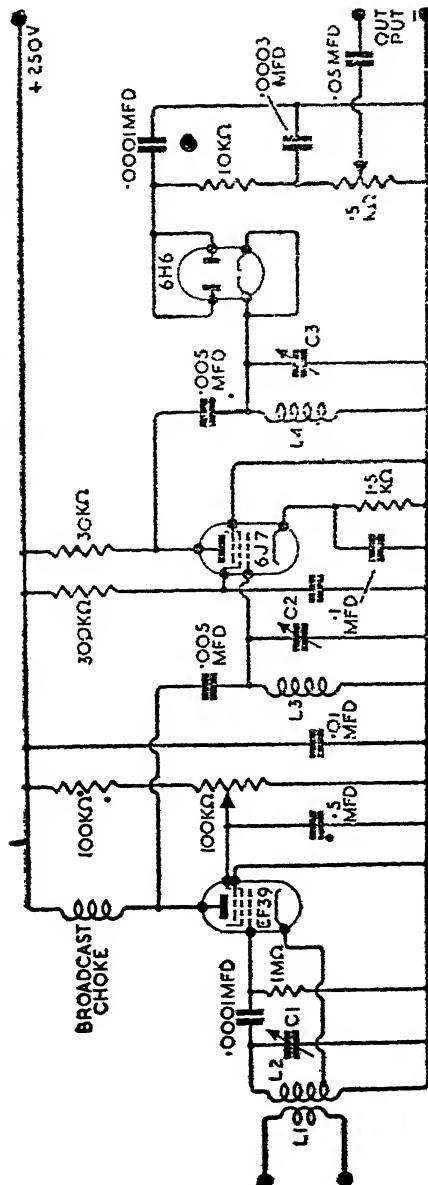
Fig. 29.
I.F. Amplifier with Autodyne Detector L1, L2, C1, V.H.F. Tuning as in Fig. 27, Cathode Tap 2 or 3 turns up ; L3, L4, "P" type Coils, PA7, tuned with ·0005 mfd. Pre-set Condensers at minimum capacity

45

and stator terminals of the variable condenser. These sockets may be made from the sheet metal, from the sockets of an old valve holder, or tubular ended soldering tags can be used. Tinning the ends of the coil keeps the contact area clean and bright.

In cases where it is impracticable to use the Acorn type valve the circuit may be modified as shown in Fig. 28, and an H.F. pentode, with its suppressor grid and screening grid connected directly to its anode, may be used in place of the Acorn. Excellent results have been obtained with the EF 39 valve type, and it is suggested that this valve or a four-volt equivalent be used for best reception.

The grid circuit is somewhat more difficult to arrange since a slightly longer lead is necessary to reach the top cap connection, and for this reason, as well as to allow for the higher internal capacitances of the valve, the coils have been reduced slightly in size to cover approximately the same waveranges.

It will be seen from the diagram that the quench circuit has also been changed, since in place of the low value resistor from grid to earth there is now a very high value resistor directly across the grid condenser, so that the grid of the valve is connected t> the H.T. supply. Care must be taken to make sure that the resistor is correct before the supply is switched on, otherwise a heavy grid current will flow and the emission of valve damaged irreparably.

One disadvantage of the super-regenerative receiver is that it is quite an efficient little transmitter of interfrence ! It should not be used in any location where there is a television receiver, for example unless care is taken to avoid tuning to the programme frequencies.

A HIGH FREQUENCY I.F. UNIT

In Fig. 29 is shown a circuit of interest to the ultra-short-wave experimenter, for the conversion of an oscillating V.H.F. detector to an autodyne superhet. Due to the wide pass band of theV.H.F. tuning system the signal can be received and, by slight de-tuning can be heterodyned by the receiver's own oscillations to produce an I.F. signal, amplified in the usual manner. An I.F. of the usual 465 kcs., however, is found too low a frequency for this purpose, due to image frequencies. and a higher frequency I.F. must be used. The circuit generally requires some

46

experimentation before the best results are obtained, but selectivity and sensitivity make it well worth while.

The simplest method of constructing the I.F. amplifier is shown in the figure. The I.F. is chosen to be about I mc., and this is obtained by the use of ordinary P type tuning coils with pre-set condensers bringing them into tune. The I.F. circuits are not, therefore, of the transformer type with two windings, but amplification is still obtained since the I.F. signals set up voltages across the coils in the same way as a received signal. A further experiment would be to tune the two coils by means of a twogang condenser, the two I.F. circuits being well shielded from each other. The I.F. would then be readily adjustable, and a measure of electrical band spread would be possible.

In any case the two P type coils must be mounted in shielding cans of adequate size and any instability can then be dealt with by reducing the screen voltage of the H.F. pentode. Naturally, a super-regenerative detector should not be used, and an electron coupled oscillating stage is shown.
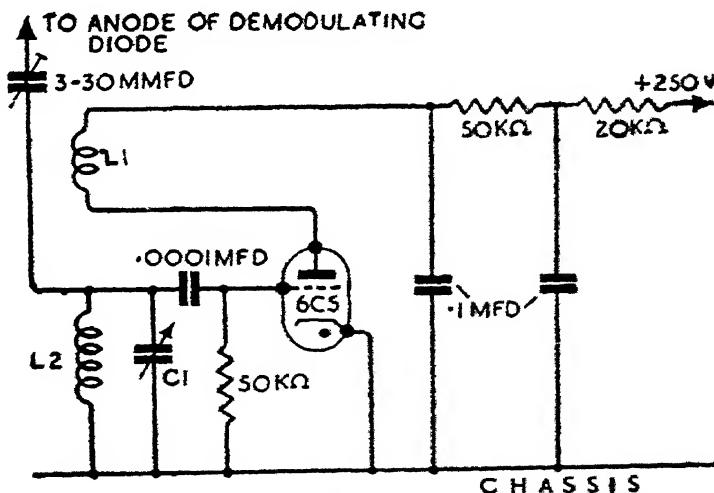
Fig. 30. Beat Frequency Oscillator. L1, L2 and C1, Commercial BFO Coil and Trimmer

A BEAT FREQUENCY OSCILLATOR

Listeners to amateur and commercial short wave stations using the morse code know that many transmissions are lost or

47
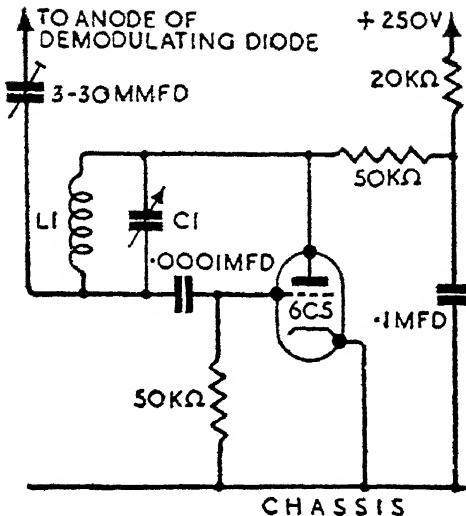
Fig. 31. Beat Frequency Oscillator L1, L2 Commercial BFO
Coil and Trimmer or IFT Coil and Trimmer to oscillate at
1,000 c.p.s. difference from Receiver's I.F.

are unreadable when the ordinary superhet circuit is used, unless the incoming signal is tone modulated, and whilst modern practice is to use tone signals it is still necessary in many cases to introduce the tone at the receiver.

Using the reacting detector, all that is necessary is to allow the circuit to remain on the edge of regeneration, when the signal will heterodyne with the detector frequency to give an audible beat note whenever the transmitter is keyed. Moreover the beat note is tunable, within limits, by de-tuning the detector, so that a pleasant copying tone is automatically obtained. With the superheterodyne, however, this is not possible, and another method of producing a tone on the signal is required.

The solution is to employ a separate oscillator which will heterodyne the signal injected from the last I.F. stage into the diode detector by beating with the I.F. signal. This means that the heat oscillator must work practically at the same frenquency as the receiver's intermediate frequency, 1,000 cycles being the usual difference, so that the beat oscillator tuned

48

circuit must be similar to an I.F. coil. Many manufacturers supply beat frequency oscillator coils, and since the usual superhet I.F. is between 465 and 470 kcs. practically any such coil may be used.

Where the whole receiver is under construction, the B.F.O. will, of course, be included on the chassis, but when it is to be added to an existing superhet it will be necessary to construct the unit in a well shielded metal box, drawing the power supply from the receiver by some such method as described on Page 48. Screening is essential, both to prevent the injection of too great a signal, and also to obviate the possibility of introducing harmonics of the oscillation frequency into the earlier tuned stages.

In Figs. 30 and 31 are two circuits suitable for the B.F.O., the second using a single coil which might be taken from an old or damaged I.F. transformer. The output is coupled through a low capacity condenser to the diode detector of the receiver, and the unit tuned to give a suitable note on a C.W. transmission.

The lead connecting the output to the diode must be short and direct, since it is possible to upset the tuning of the receiver I.F. stage by capacity coupling, and the unit, whether built into a receiver or used externally, must be fitted with its own on-off switch since it obviously will not be required on any signal other than a code transmission.

THE LOUDSPEAKER

Whilst extension speakers are fitted in many households, there is seldom provision for separate control of volume or tone on the extension unit, which is generally left to work at the same level as the receiver speaker. The method of tone and volume control will vary according to the manner in which the extension speaker is fed since in some cases the voice coil is switched directly to the secondary of the output transformer of the receiver itself, whilst in others the extension speaker includes its own output transformer.

Where the receiver's transformer feeds the extension voice coil, the first point of consideration is the leads to the extension unit. These will be carrying relatively heavy currents at low voltages and must, therefore, be substantial to avoid line losses.

49

Volume control at the extension speaker is simply provided by a series of variable resistance of about 50 ohms, connected as shown in Fig 32. Tone control can theoretically be obtained by including condensers in the circuit, but their capacity needs to be so large that the method is quite impracticable and the tone of the extension speaker must be controlled at the receiver end of the line along with the internal speaker.

Where the extension speaker includes its own output transformer, the leads to it are carrying only small currents at relatively high audio voltages. It is also possible for the leads to be at a high potential above earth, particularly in the case of an A.C /D.C. receiver, and in situations where this is inconvenient or dangerous the extension speaker may be isolated from the high potential side of the power pack by using a condenser coupling as in Fig. 33. If it is desired to switch out the internal speaker when using such a circuit, the secondary of the internal transformer must be switched from the voice coil of the receiver speaker into a similar resistive load as shown in Fig. 34.

Using the high voltage-low current line to the extension transformer, it is possible to lose high note response due to the capacity between the wires in a speaker line of twisted flex or similar material. If the extension speakers are near earthing points it may be possible, with the condenser filter system, to use only one wire to the extension units with an earth return, but if a two-wire system must be used one method of reducing line capacity is to separate the wires, running one along the skirting and the other along the picture rail. Probably the best type of volume control is a variable resistance in series with the transformer primary, whilst a high note attenuator, the usually required tone control, is shunted across the transformer as shown in Fig. 35. A more comprehensive tone control is shown in Fig 36, where either high or low note cutting is obtainable.

SPEAKER RESPONSE

Those with a spare loudspeaker may care to experiment in extending its frequency response range. Bass notes are reproduced by movements of the whole cone, so that the bass response is extended by making the mounting of the cone more flexible. This is achieved by very carefully painting the "roll" —the embossed rim of the cone—with a solution of glycerine
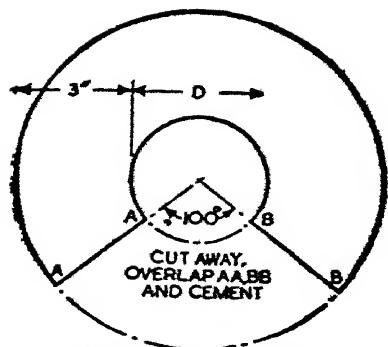
DIAMETER "D" OF CENTRE
HOLE = 1¾ DIA. OF SPIDER

Fig. 37
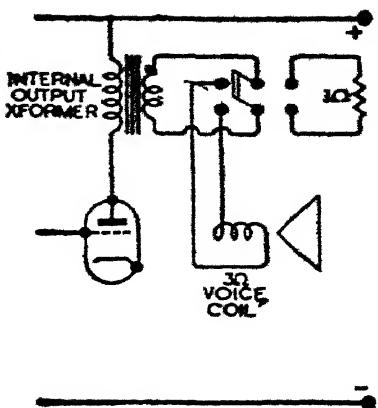
Fig. 34
Switch in out the Internal Speaker

Fig 32
Volume Control using Low
Resistance Extension Speaker
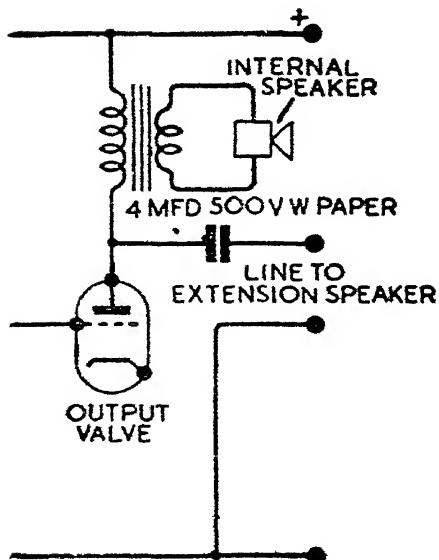
Fig. 33
Isolating the Extension Speaker
from the Power Line

in water, equal parts of each being used. The solution must be applied very sparingly, since it has a spreading effect, and will gradually merge further into the cone to give a graduated soft edge which will allow greater cone excursions.

The high notes of the treble are handled by the centre of the cone, especially in the spider and its mounting ring. To accentuate the treble a subsidiary cone may be mounted within the main cone, formed from cone material cut and shaped as shown in Fig. 37. This subsidiary cone is cemented to the main cone at the junction of the cone and the spider.

REGENERATION IN THE I.F. AMPLIFIER

The I.F. circuits, transformers, etc , in the ordinary receiver are so arranged that a band pass effect is obtained, the pass band being sufficiently wide for the correct reception of musical frequencies yet not so wide as to allow spurious beat notes or heterodyne frequencies to pass as well. Even so, in reception of amateur stations and on the crowded commercial bands the pass frequencies of the I.F. transformers are sometimes too wide, so that more than one station is heard in the loudspeaker. One remedy is to use variable selectivity I.F. transformers, but a more easily incorporated manner of increasing the transformer selectivity is to introduce reaction on one of the circuits, generally the first I.F. amplifying valve.
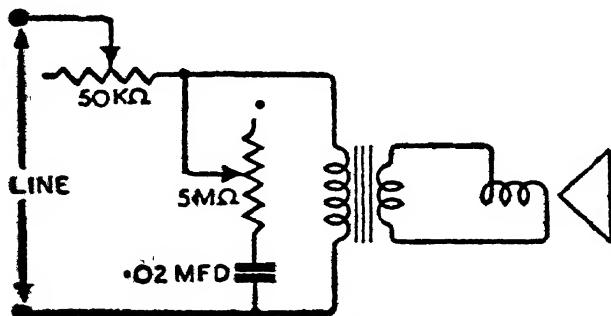
Fig. 35. Volume and Treble Cut Control on Extension Speaker

As is well known, in any tuned circuit the response curve can be sharpened to a very great degree by the use of regeneration, and this holds good for I.F. transformers. The regener-

ation is not obtained by means of a reaction coil, however, but the simple method of inserting a small capacity of a size which must be determined by experiment between the grid and anode of the I.F. valve. This gives sufficient feedback to sharpen the resonance curve and, if the capacity is too great, sufficient to set up actual oscillation in the I.F. circuit, which is, of course, undesirable.

The size of the capacity depends upon the inherent stability of the I.F. circuit, which varies widely in different receivers. In some cases a wire soldered to the grid cap of the valve and bent so that it runs down beside the valve for an inch or so, the other end being left unconnected, gives sufficient capacity with the valve's anode to set up the regeneration required. Again, in other cases it may be found necessary to connect a ceramic 30 mfd. trimmer direct from anode to grid, the trimmer being adjusted for the correct capacity.
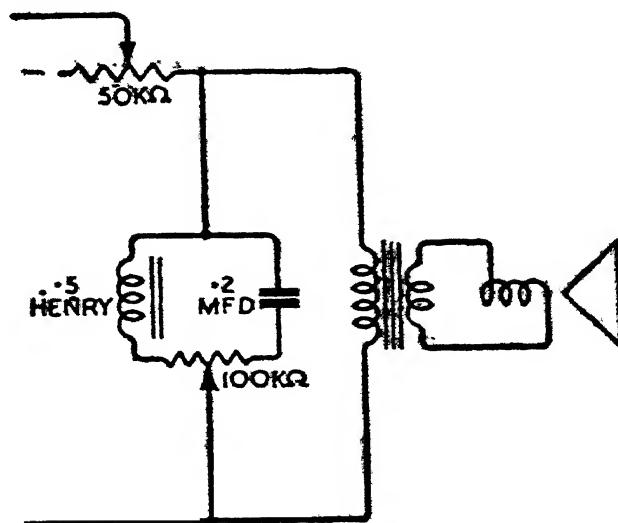
Fig. 36. Volume, Treble and Bass Cut Control on Extension Speaker

In general, the greater the stability of the I F. amplifier, and the more efficient the screening, the better. Constructors of superhet circuits should always make a point of building the best I.F. amplifier that can be obtained, since the greater part

53
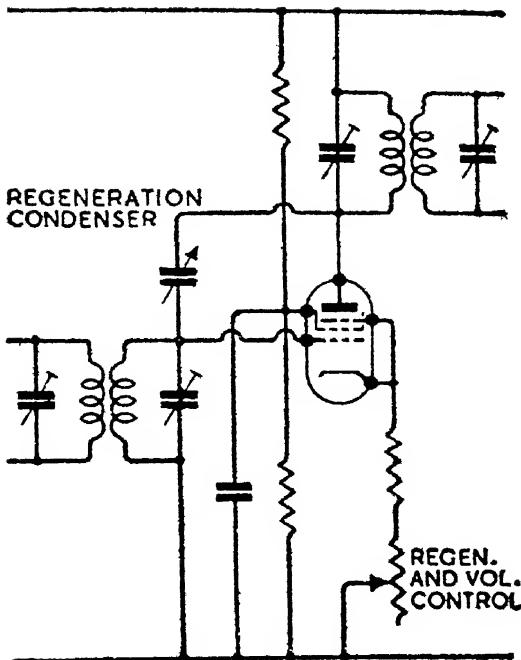
Fi . 38. Outline Circuit showing addition of Regeneration to
an I.F. Stage

of the amplification and selectivity are both obtained from these
circuits. Single earthing points for each stage as in V.H.F.
work, are a definite advantage, and a screen voltage no higher
than the valve manufacturer's figure should be used. Increasing
the screen volts will give little extra in the way of amplification,
whilst stability might be gravely impaired.

The simple principle of introducing the regeneration in the
I.F. stage is shown in Fig. 38.

It must always be remembered that as the regeneration is
increased the frequency pass band is lowered, so that quality is
lost. The scheme, therefore, is recommended only for amateur
speech and morse reception, and not for ordinary broadcast use.

The stage shown in the diagram, using a variable-mu valve,
has the added advantage that the regeneration can be controlled
by means of the bias resistor. It may be found necessary to

Fig. 39.

Single-ended Output Stage

+250

2,500Ω
OUTPUT
LOAD

6L6

·1 MFD

·25 MΩ

50MFD
25VW

170Ω

Push-Pull Output Stage

+250V

10,000Ω
OUTPUT
LOAD

6V6

6V6

200Ω

6C5

·1 MFD

·25 MΩ

·25 MΩ

·1 MFD

50KΩ

1KΩ

50KΩ

·1 MFD

·25 MΩ
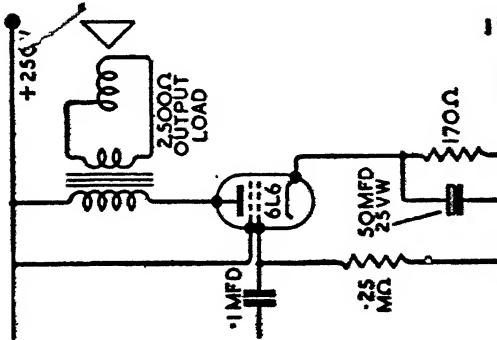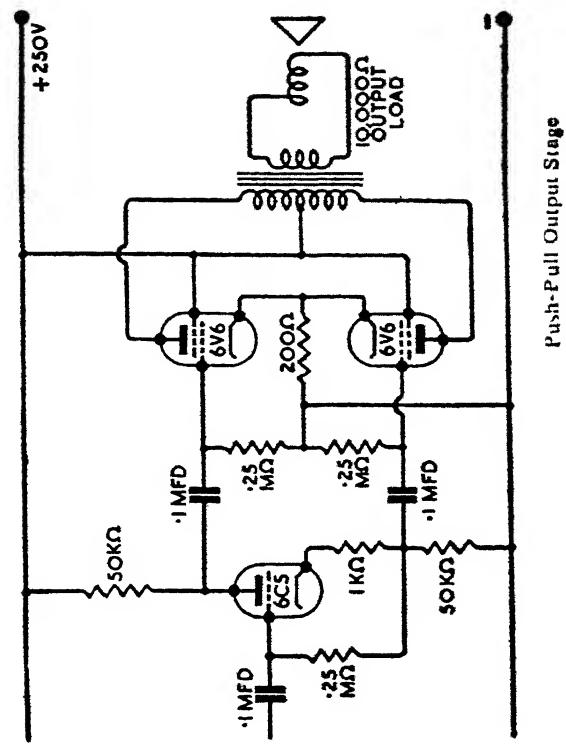
increase the value of this resistance above its usual amount to avoid overloading on strong signals.

ADAPTING TO PUSH PULL OUTPUT STAGES

The advantages of the push pull output stage are well known, especially in respect of their qualities of balancing out second harmonic distortion and the giving of large outputs, and it appears to the writer that several single ended output stages might be adapted to p.p. output stages with little trouble.

The first consideration is to compare the input to the present output valve's grid with the required input to the grids of the proposed valves to discover what adaptation, if any, is to be made in the first stages of the amplifier or other apparatus on which the work is to be carried out.

The grid input voltage may in most cases be taken as the grid bias voltage as given for the valve in the maker's data sheet, and a low voltage will give poor output whilst too great a voltage will overload the output stage with consequent distortion.

To take an actual case as an example, consider changing a single ended 6L6 output stage, giving 6 watts, to a p p. stage. The Radio Valve Manual, No. 30 in Bernard's List, shows that the 6L6 draws a total of 80 mA. (anode and screen) at 250 volts, and has —14 volts bias. Thus it is required to find a pair of valves which need approximately 14 volts for the pair if the new stage is to be added without undue adjustments to the rest of the circuit.

Running through the output valves in the Manual shows that a pair of 6V6 valves, in Class AB1, will operate with 75 mA. total anode and screen currents with a bias of —15 volts. The loudspeaker load for the 6L6 was 2,500 ohms, whilst for the 6V6s it must be changed to 10,000 ohms, but since a new push pull output transformer with centre tapped primary winding would be required in any case, this is of little importance. The new output with the p.p. stage is given as 8.5 watts, although the actual output will probably be a little lower due to slightly underloading the grids.

The new stage needs to be driven from a phase splitting circuit which will introduce no amplification, so the well known concertina" stage may be used. The original input line to the 6L6 is now fed to the phase splitting grid and the double

56

output taken to the 6V6's. The screens may be run directly to the H.T. line, since they are rated at 250 volts, and the new circuit, compared with the old single ended stage, is shown in Fig. 39.

It may, however, be required to add a similar valve to an existing output stage, for example, the single 6L6 might be doubled. This means that the H.T. supply line will be called upon to deliver a total of 145 mA. for the anodes and screens of the output stage alone, but presuming this is within the scope of the power pack we must now find the input requirement so far as the grids are concerned. The Manual shows that two 6L6's in Class A push pull must be biased to —17.5 volts ; in other words, the stage which adequately fed the single 6L6 cannot quite cover the needs of the p.p. pair. The extra voltage, however, is only of a small order, not sufficient to warrant another valve stage, and it is possible to obtain the small step up and to split the phases for the two grids at the same time by the use of an intervalve transformer. Not every transformer is suitable for this task. A really good instrument must be used if results are to be worth while. It is, however, unnecessary to use a split secondary transformer as Fig. 40 will show. The phase splitting may be carried out across the secondary by the use of resistors. The transformer primary circuit must be well decoupled.

The anode load, plate to plate, of the two 6L6's is 5,000 ohms in place of the original 2,500 ohms.

These schemes, as outlined, will naturally work as well with English type valves.

A CURRENT ECONOMISER FOR BATTERY SETS

It is always desirable to keep the drain on the battery of a portable or fixed battery set as low as possible in order that the battery life is not unduly shortened, but at the same time the output to the loudspeaker must be adequate for good listening and programme value. There must therefore be a balancing point between the size and type of output valve in use and the capabilities of the H.T. battery. It is possible to effect a saving in battery drain without affecting volume by using a metal detector, the Westector W4, in what might be described as a low frequency A.V.C. circuit.

Fig. 40. Adding a 6L6 to a Single 6L6 Stage. Compare with Fig. 39.

41.
Battery Economi er

58
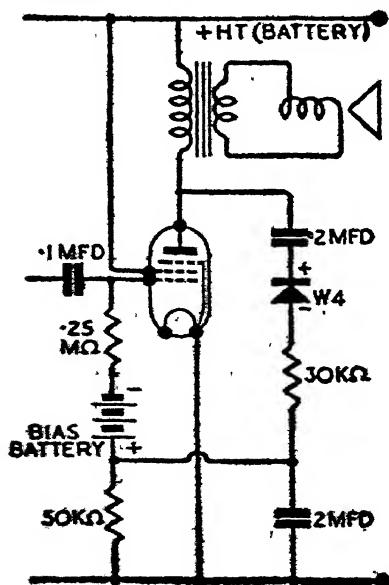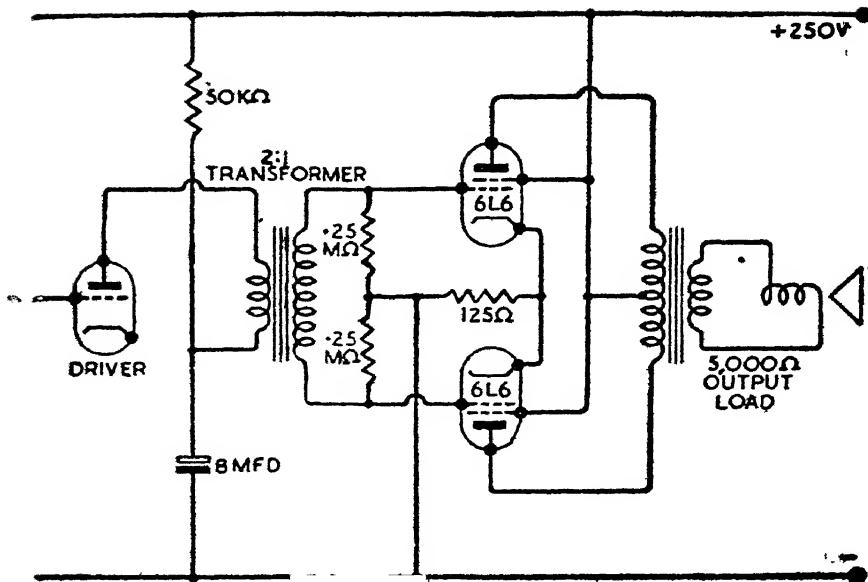
The scheme, shown in Fig. 41, is easily understood. The output valve is biased to an extent which causes it to draw only a small anode current. Naturally this means a small output swing in the anode load, but for weak signals there would be no point in passing a greater anode current. For strong signals, however, the circuit requires readjustment of the high bias voltage, and this is carried out automatically by the W4. Part of the signal is rectified and fed back into the grid circuit as a positive voltage which has the overall effect of neutralizing part of the high negative bias and allowing the valve to operate on its normal working curve. The anode current therefore varies with the signal, and the battery drain is far more proportional to results than would otherwise be the case.

In putting the scheme into operation the bias for any valve must be found by experiment—a simple matter since it is only necessary to increase the bias to the point where further increase would introduce distortion. It must be remembered that no valve should have its bias changed without switching off beforehand.

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RADIO RECEIVER

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FIVE VALVE
C I R C U I T S

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